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RESEARCH PAPER

CHANGES IN SERUM LACTATE TO AEROBIC EXERCISE AMONG AMATEUR ATHLETES AND NON-ATHLETES

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ABSTRACT

Lactate is an end product of glucose metabolism that is usually produced in a larger quantity during exercise. This increase in production during exercise has been understood to be the reason for fatigue. The aim of this study is to determine the responses of serum lactate to aerobic exercise among amateur athletes and non-athletes. 48 consenting males (24 amateur athletes and 24 non-athletes) participated in this comparative quasi-experimental design. Subjects cycled on a bicycle ergometer to attain moderate intensity exercise target heart rate (MIETHR) and maintained the MIETHR till exhaustion (15 on Borgs scale or volitional exertion) while the serum lactate was measured at intervals. Data were analyzed with descriptive statistics and inferential statistics of Analysis of variance (ANOVA). Alpha level was set at $p < 0.05$. The mean age of the participants was 26.08±2.28 and 28.13±1.51 for the athletes and non-athletes respectively. There was a significant difference p=0.001 Training induced adaptations include a lower serum lactate level, a point that should be noted in studying of metabolic adaptations.

Keywords: Lactate, Athletes, Exercise, Response, Fitness

INTRODUCTION

Physiological processes in the body respond to varying degrees during exercise to enable the body adjust to the demand placed by the exercise programme (Brooks, 2000). However, these responses vary in individuals depending on a lot of factors which may include age, sex, body mass index, (Astrand *et al*., 2003; Brooks, 2000; Ogawa et al, 1992) etc. So also, fitness level or activity levels of individuals have also been identified as one of the factors affecting the rate at which the body responds to exercise (Niemann, 2011; Plowman and Smith, 2011; Manley, 1996).

Adaptation has been observed to play a role in influencing the rate at which these physiological processes are altered in the body during exercise. Several studies (Saltin and Rowell, 1980; Holloszy, 1984; Terjung, 1995; Ross and Leveritt, 2001; Manna *et al*., 2011; Rivera-Brown and Frontera, 2012) revealed that the body of athletes/amateur athletes responds differently to a varying degree to changes in the physiological process during exercise when compared to non-athletes or sedentary individuals due to adaptation which resulted from consistent training. Training gives rise to different fitness level and is determined by the level of time put into training which is influenced by the incentive that is attached to the sports being engaged in (Hornby *et al*., 2010). This classifies the athletes into professional athletes and amateur athletes. Amateur athlete is a person who engages in a pursuit especially a sport, on an unpaid basis or a person who engages in an activity especially as a pastime rather than professionally for gain (Hornby *et al*., 2010).

Blood lactate levels reflect the balance between lactic acid production (appearance) and clearance (removal). Lactate clearance occurs primarily by three processes: Oxidation (50–75%), Gluconeogenesis (10–25%) and Transamination (5–10%). All three processes can involve the movement of lactate, either within or between cells. Lactate is produced as lactic acid, but at normal physiological pH, more than 99% quickly dissociates into lactate (La^-) anions and protons (H^+) (Brooks, 2000). Lactate moves readily between cytoplasm and mitochondria, muscle and blood, blood and muscle, active and inactive muscles, glycolytic and oxidative muscles, blood and heart, blood and liver, and blood and skin (Brooks, 2000; Plowman and Smith, 2011). Lactate moves between lactate-producing and lactate-consuming sites through intracellular and extracellular lactate shuttles (Brooks, 2000).

During heavy exercise, lactate becomes the preferred fuel of the heart (Plowman and Smith, 2011). In this manner glycogenolysis in one cell can supply fuel for another cell. In each of these cases the ultimate fate of the lactate is oxidation to ATP, CO_2, and H_2O by aerobic metabolism (Brooks, 2000). Lactate circulating in the bloodstream can also be transported to the liver where it is reconverted into glucose by the process of gluconeogenesis. The liver appears to preferentially make glycogen from lactate rather than glucose (Plowman and Smith, 2011). In human glycolytic muscle fibers (both fast-twitch oxidative glycolytic and fast-twitch glycolytic), some of the lactate produced during high-intensity exercise is retained, and in the post-exercise recovery period it is reconverted to glycogen in that muscle cell. This process is called glyconeogenesis (Brooks, 2000). However, there is paucity of studies investigating the serum lactate responses to aerobic exercise among amateur athletes and non-athletes. Hence the essences of this research study.

MATERIALS AND METHODS

Study Area: The study location was at the Osborn la - palm gym at Kpiri Kpiri, Abakaliki in Ebonyi State, South East, Nigeria. Abakaliki is the capital city of Ebonyi State in South - eastern Nigeria, located at kilometer 64, South-east of Enugu State (Hoiberg, 2010).

Study Design: The study utilized a quasi-experimental design. The subjects were grouped into by convenience using selection criteria. A total of forty-eight (48) participants were recruited for this study. The participants were divided into two groups, the athletes group (24) and the non-athletes group (24). The athletes group was recruited from among the amateur athletes that have represented their various states in the national sports festival and still comes out for training at the Abakaliki township stadium while the non-athlete group was recruited from members of the public who volunteered to participate. The participants' age ranged from 22years to 30years.

Ethical Approval: Ethical clearance was obtained from the Health Research and Ethics Committee of the University of Nigeria Teaching Hospital, Ituku-Ozalla, Enugu State. After critical study of the research proposal, a written approval was signed by the committee. Participants were fully informed about the experimental procedures, risks and protocols after which they gave their signed informed consent.

Inclusion/Exclusion criteria: Amateur athletes within the age range 18-30 years that participate in at least one-hour training three times a week and had also participated in a national competition were recruited alongside non-athletes within the age range 18-30 years who have not performed any form of regular exercise in the last six months. Professional athletes and participants with musculoskeletal problems and/or history of cardiovascular or cardiopulmonary diseases were excluded from this research.

Data Collection: Homogenous environment was maintained by choosing a convenient time in the evening hours (4pm to 7 pm) for the study to be carried out in the Osborne la Palm Gymnasium, Abakaliki, Ebonyi State. A uniform room temperature was maintained using the air conditioner in the gym. The participants rested for 20 minutes in an arms chair, after which the anthropometric data and baseline serum lactate were measured and recorded. The participants climbed the stationary bicycle ergometer and cycled for 5 minutes as warm up with no resistance in the bicycle ergometer, after which the serum lactate was measured and recorded again. Then the ergometer was set on a resistance of grade two and the participants cycled till the Target Heart Rate (THR) for moderate intensity exercise was attained (65% - 75% of maximum heart rate calculated using the Karvonen formula). Lactate Plus analyzer produced by Nova Biomedical, Waltham, MA, USA was used to determine the blood lactate level. It is a portable, compact and accurate lactate meter for performance diagnostics and training monitoring. It determines plasma lactate levels quantitatively (in mmol/L) on 0.6μl of whole blood by the use of a reagent strip of an enzyme-coated electrode and a small meter within 15 sec. The hand-held device's measuring range is between 0.3 and 25.0 mmol/L for human. It has high reliability (test-retest and day-to-day) and validity. (Kulandaivelan, 2009). Lactate plus test strip is reagent strip of an enzyme-coated electrode designed for use in the lactate plus meter. (Kulandaivelan, 2009). On Attainment of Target heart Rate (OATHR), serum lactate was measured and recorded again. Once the THR has been attained by the participant, the participant was instructed to maintain the THR range by either increasing or decreasing the speed of cycling. The participant continued cycling while maintaining the THR range for moderate intensity exercise and the serum lactate were measured and recorded at five-minute Post-Attainment of Target Heart Rate (PATHR), ten minutes PATHR, fifteen minutes PATHR and twenty minutes PATHR. Afterwards, participants were allowed to cycle until exertion (15 on borgs scale or volitional exertion) and serum lactate measured too.

The participants were escorted to an arms chair, where they rested for five (5) minutes and serum lactate measured and recorded.

Statistical analysis: Data was summarized using descriptive statistics of mean and standard deviation. Inferential statistics of ANOVA was used to analyse the serum lactate difference between the two groups. The level of significance was set at $p < 0.05$.

RESULTS

The minimum age of the subjects in the athlete group was 22 years and maximum age was 32 years with a mean of 28.13±1.51 years while the minimum age of the subjects in the non-athlete group was 25 years and the maximum age was 30 years with a mean of 28.13±1.51years.

Table 1: Physical Characteristics of Subjects in Both Groups.

	Athlete $\bar{\mathbf{X}}$ ± SD	Non-athletes $\bar{\mathbf{X}}$ ± SD
Age (years)	26.08 ± 2.28	28.13±1.51
Height (cm)	174.88 ± 6.63	169.21 ± 2.37
Weight (kg)	72.40 ± 6.67	71.01 ± 7.63
BMI (kg/m^2)	23.61 ± 0.85	24.84 ± 2.90

*Correlation is significant at the 0.05 level (2-tailed)
Key: $\bar{\mathbf{X}}$ = Mean; SD = Standard Deviation; BMI = Body Mass Index

Table 2: Serum lactate Response during the Ten Different intervals among amateur and non-athletes

Variable	**Athletes**		**Non-athletes**	
Lactate	**Mean**	**SD**	**Mean**	**SD**
At rest	2.47	1.83	1.71	0.72
5 Mins warm up	2.88	0.83	3.81	3.35
On attainment of THR	5.19	1.81	5.55	2.43
5 Mins Post ATHR	4.86	2.34	7.88	2.79
10 Mins Post ATHR	5.14	1.73	6.31	3.43
15 Mins Post ATHR	4.48	1.83	6.30	3.36
20 Mins Post ATHR	4.37	1.59	3.99	1.41
Mean Exc Phase	4.48	1.10	5.84	2.81
Exertion	3.73	2.30	5.03	2.04
5 Mins REST PEx	2.45	0.95	3.90	1.18

KeyS: Mean represents mean of lactate in mmol/l; SD = standard deviation; THR=target heart rate; ATHR=attainment of target heart rate; PEx: post exertion

Table 3: Two Factor Analysis of Variance (ANOVA) of Serum lactate Response among Amateur Athletes

Source of Variation	SS	Df	MS	F	P-value	F crit
Between Subjects	180.872	23	7.864	3.365	0.000*	1.588
Within Subjects	**237.043**	**8**	**29.630**	**12.680**	**0.000***	**1.989**
Error	429.944	184	2.337			
Total	847.858	215				

*Correlation is significant at the 0.05 level (2-tailed)
Key: SS = Sum of Squares; Df = Degree of freedom; MS = Mean of Squares

Table 4: Two Factor Analysis of Variance (ANOVA) of Serum Lactate Response among Non-Athletes

Source of Variation	*SS*	*Df*	*MS*	*F*	*P-value*	*F crit*
Between Subjects	483.158	23	21.007	3.766	0.000*	1.588
Within Subjects	**675.456**	**8**	**84.432**	**15.139**	**0.000***	**1.989**
Error	1026.169	184	5.577			
Total	2184.782	215				

*Correlation is significant at the 0.05 level (2-tailed)
Key: SS = Sum of Squares; Df = Degree of freedom; MS = Mean of Squares

Table 5: Two Factor Anova Comparing Serum Lactate Response between Athletes and Non Athletes

Source of Variation	*SS*	*Df*	*MS*	*F*	*P-value*	*F crit*
Sample	46.086	1	46.086	8.999	0.003*	3.864
Columns	752.685	8	94.086	18.372	0.000*	1.961
Interaction	**159.813**	**8**	**19.977**	**3.900**	**0.000***	**1.961**
Within	2120.142	414	5.121			
Total	3078.727	431				

*Correlation is significant at the 0.05 level (2-tailed)
Key: SS = Sum of Squares; Df = Degree of freedom; MS = Mean of Squares

DISCUSSION

Results of the study showed that there was a significant difference in the serum lactate response to aerobic exercise within and between the two groups (amateur athletes and non-athletes) studied. Blood lactate level in amateur athletes returned almost to baseline at five minutes' rest post exercise but was not the same in non-athletes. From the above observation it could be seen that blood lactate a product of metabolism is higher at rest among the amateur athletes than among the non-athletes; this is supported by the works of Sjodin *et al* (1996) and Fransilla-Kallunki and Groop (1992) which suggested that there is higher basal metabolic rate among amateur athletes than the non-athletes thus lending a support to the result of this work.

The post-hoc analysis revealed significant differences on attainment of target heart rate, five minutes PATHR, ten minutes PATHR, fifteen minutes PATHR and on exertion in non-athletes while amateur athletes showed significant differences on attainment of target heart rate, five minutes PATHR, ten minutes PATHR, fifteen minutes PATHR, 20 minutes PATHR and on Exertion. On comparing the two groups, there was a significant difference; this suggests that the rate of serum lactate accumulation during moderate intensity exercise could be higher in non-athletes compared to amateur athletes. This can be explained by the assertion that trained people experience lower serum lactate than untrained people when exercising at the same absolute workload (Triplett-McBride, 1996). This was in agreement with the result of the study done by Brooks, (2000) and Bonen, (2000) which revealed that athletes stay fit by training and such training generates big lactate load that the body adapt by building up mitochondria for quicker clearance of serum lactate to prevent accumulation. Tarnopolsky *et al*., 2006 and Carter *et al*., 2001 revealed that training enables growing of mitochondria in muscle cells, the mitochondria which is the power house of the cell where lactate is burned for energy.

Also, the result of this study shows that serum lactate level in amateur athletes returned almost to baseline value at five minutes after rest post exercise but was not the same in non-athletes thus suggesting that the rate of serum lactate clearance in the body may be higher in amateur athletes compared to athletes. This indicates that training induced adaptations include a lower serum lactate level at any given workload. The result of this study was in agreement with the results of similar study done by Gollnick *et al*., 1986; Pierce *et al*., 1987; Triplett-McBride, 1996; Manna *et al*., 2011 and Martorelli *et al*., 2015, who opined that training increases the rate of lactate clearance in both aerobically and anaerobically trained athletes compared to untrained individuals. There reasons could be because that the trained subjects have a more active lipid oxidative metabolism and a suggestion that clearance of lactate in the body is an indicator of a person's ability to recover from exercise. Training induced adaptations include a lower serum lactate level during exercise, a point that shows that during activity, serum lactate is being cleared faster among the amateur athletes than the non-athletes. This would be an advantage to the amateur athlete whose lactate is being used cleared up faster to avoid fatigue or being used up faster in generating energy as the case may be. This should be noted in studying of metabolic adaptations and understanding of the true role of lactate either as a precursor to fatigue or a fuel for the body.

LIMITATIONS

The sample size is a limitation for generalization of the results of this study.

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AUTHORS CONTRIBUTIONS

Anekwu Emelie Moris was responsible for the design of the study and gathering of literature materials, Charles Ikechukwu Ezema and Ojukwu Chidiebele Petronilla were responsible for the review of literature and the drafting of the manuscript, Ogechukwu Ngozi Ojeniweh, John Davidson, Udeh Chinonso, Ohotu Edwin Obiora and Anekwu Esther Onyeka were responsible for the collection of data in the field, analysis of the data and presentation of the data; Goddy Chuba Okoye the supervisor of the research work and the organizer of the manuscript.